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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105

OFFICE OF
AIR AND RADIATION

October 29, 1990

MEMORANDUM

SUBJECT: MMT Testing Program Report

FROM: J. Bruce Kolowich, Manager
Fuels and Chemistry Services

TO: Mary Smith, Director
Field Operations & Support Division

THRU: Richard D. Lawrence, Director
Engineering Operations Division

Attached is the complete description and summary of the testing program to determine the effects of MMT on exhaust emissions.

Attachment

Studies on the Effects of MMT Use on Vehicle Emissions

1.0 INTRODUCTION

Ethyl Corporation submitted a recent fuel additive waiver application to the Environmental Protection Agency, proposing the nationwide use of methylcyclopentadienyl manganese tricarbonyl (MMT) as an octane enhancer in unleaded motor vehicle fuel. In previous applications, Ethyl Corp. had made similar requests, and response from the agency had centered on the need for a comprehensive test program before any waiver involving the use of MMT could be granted. As a result, this most recent waiver application contained the results of a major study intended to confirm the hypothesis that MMT use at 1/32 g(Mn)/gal caused no ill effect to the emission control systems of current automobiles. (See EPA AIR Docket A-90-16)

Among the conclusions presented with the study were the theories that MMT use contributed to a lessening in the amount of nitrogen oxides, carbon monoxide, and total particulate emitted over the life of the vehicle (when compared to an identical vehicle who's fuel contained no MMT), and that manganese emission was limited to, on average, 0.4% of the amount introduced to the engine. One further result of the study stated that increased hydrocarbon emission, a problem with MMT use in earlier studies, was limited to 4% relative to the applicable hydrocarbon standard. This work was originally undertaken in an attempt to confirm some aspects of the Ethyl submission, especially with respect to manganese emissions.

The waiver process allows the agency 180 days from date of receipt of the waiver application to reach a decision on the waiver. The last day for a decision on this waiver application is November 5, 1990. Testing and technical support from EOD was requested on July 27, 1990. The test program commenced immediately and was completed on October 19, 1990. Due to the limited time available the focus of the program was to address unresolved technical questions which were surfacing while reviewing the waiver application.

1.1 Testing and Mileage Accumulation Fuels

All vehicle tests were run using Phillips 96 RON Certification Gasoline. Additionally, all tests completed during the investigation used fuel from the same batch of Phillips Unleaded Test Gasoline (UTG). The measured parameters for this batch of UTG are included in Attachment A. When tests were carried out with UTG containing no MMT, these vehicles were fueled directly from the dispensers normally used for certification testing. These dispensers maintain the fuel at or near 45°F. When MMT containing fuel was used for testing, the fuel was maintained at or near this temperature by virtue of its storage in

a fuel conditioning cart. Only one cart was used for all MMT containing test fuel. In preparing the MMT containing test fuel, the cart was first filled to near capacity with UTG from the dispenser, and the appropriate amount of MMT was added. The fuel was allowed to mix in the cart for between 20 and 60 minutes, and a sample was removed for manganese analysis. In all cases, manganese concentration was verified to be between 0.029 and 0.033 g(Mn)/gal* before any test was commenced with the fuel. The cart used for containing this fuel was a Horiba model #73 FCT, and contained its own internal refrigeration system. As a precaution, one test was run with fuel from the cart before the addition of HITEC to verify that non-MMT fuel from the cart gave results consistent with those of fuel directly from the dispenser.

A second base fuel was procured for the purpose of mileage accumulation. This fuel was a Gulf commercial regular gasoline. The pertinent measured parameters for this gasoline, both before and after MMT addition, are shown in Attachment B. One thousand gallons of this fuel was placed in an underground storage tank, and the appropriate amount of MMT added. The fuel was mixed overnight with the tank's internal pump, and a sample of the fuel was analyzed for manganese content before any mileage accumulation was begun.

1.1.1 MMT Sources

Two sources of MMT were used during the course of the program. The initial source of MMT was an over-the-counter commercial additive. Manganese analysis of this product was consistent with the propriatary analysis supplied by the manufacturer. This was the source of MMT for the Gulf commercial regular gasoline used in initial mileage accumulation, as well as the source for early testing. The last tests using the commercial additive as the source for MMT in this program were run on 9/6/90.

On September 6, 1990, Ethyl Corp. visited the EPA Motor Vehicle Emission Laboratory (MVEL) in Ann Arbor, MI for the purpose of delivering a sample of their MMT, known commercially as HITEC 3000. Agents of the Ethyl Corporation witnessed and aided in the blending of the initial batch of fuel containing HITEC 3000, to be used for testing at (MVEL). All testing performed subsequent to this date used only HITEC 3000 as an MMT source. A sample of this initial batch of fuel was given to Ethyl for their parallel analysis.

1.2 Vehicle Selection and Procurement

1.2.1 American Vehicles

A total of six American vehicles were acquired for testing purposes. All of these were procured on short term lease arrangements

* 1/32 g/gal=.03125 g/gal

through EPA's on site contractor, E G & G automotive research. As an approximation, these vehicles were acquired in pairs as the testing program grew. The two initial vehicles were a 1990 Ford Taurus, Veh #8888, and a 1990 Chevrolet Cavalier, Veh #0099. These models were selected due to their availability, and the fact that similar models were included in Ethyl's testing program. When initially procured, these vehicles had relatively low mileage, Veh #8888 began with 3883 miles, and Veh #0099 with 2160 miles.

The third and fourth vehicles were acquired approximately three and five weeks into the program. An additional Cavalier, Veh #0077, was acquired after three weeks for the purpose of repeating the testing on Veh #0099 for comparison. Most of the testing on Veh #0099 was performed with the commercial additive as the MMT source, but all tests on Veh #0077 were performed with HITEC 3000 as the MMT source. An additional Taurus, Veh #0024, was acquired after five weeks to serve as a pseudo-control vehicle for comparison to Veh #8888. When acquired, Veh #0024 had 11,508 miles accumulated, compared with the 11,912 miles accumulated on Veh #8888 just prior to its final testing sequence.

The final pair of American vehicles were acquired September 24, 1990, as an effort to diversify the testing fleet. These two models included a 1991 Pontiac Sunbird, Veh #0041, acquired with 4170 miles, and a 1991 Dodge Dynasty, Veh #0051, with 2126 miles. Both vehicles were subjected to testing with clear UTG and with UTG containing 1/32 g(Mn)/gal HITEC 3000.

1.2.2 Canadian Vehicles

Three Canadian vehicles were obtained on short term lease for testing. The use of MMT has been permitted in Canada since 1986 at levels of 1/16 g(Mn)/gal (0.062 g(Mn)/gal) and below. Since within the time frame of this program it was impossible to accumulate mileage at levels comparable to the Ethyl study, the use of Canadian vehicles was an attempt to simulate the use of MMT for high mileage.

The first of these vehicles was a Chevrolet Corsica, Veh #0011, acquired with 24,338 kilometers accumulated. One testing sequence on each MMT source (the commercial additive and HITEC) was completed. This vehicle was selected because it was of the same engine family as Vehicles #0099 and #0077. The second Canadian vehicle was a GMC 3/4 ton van. This light duty truck, Veh #0021, was tested twice on the commercial additive, and twice on HITEC 3000, with a single testing sequence on UTG in between. The truck was acquired with 53,522 kilometers accumulated. These two vehicles were specifically acquired from rental agencies in the London and Hamilton, Ontario areas respectively, as it was felt that procurement from the interior of Canada would insure that very little of the mileage accumulated on them would have resulted from (MMT free) U.S. fuel.

The third Canadian vehicle was also a light duty truck. This vehicle, #0031, was a Chevrolet 1/2 ton van, acquired from Windsor, Ontario with 13,384 kilometers accumulated. This vehicle was tested twice, both with HITEC 3000. Since it was acquired from a rental agency so near the U. S./Canadian border, there was less confidence that all of the accumulated mileage was on MMT containing fuel; however, the fuel in the vehicle was analyzed upon its receipt at the MVEL, and was found to contain 0.048 g(Mn)/gal.

1.2.3 Ethyl Test Vehicles

Following the bulk of the testing of the first nine vehicles, Ethyl was approached about the possibility of testing two or three pairs of the cars from Ethyl's testing fleet at the EPA MVEL in Ann Arbor, MI. Representatives from Ethyl agreed to allow EPA to perform the testing, and three sets of paired vehicles were driven from the ECS testing labs in Livonia, Michigan to MVEL. All of these vehicles were 1988 model year, and were identified as Ethyl test vehicles G1 (non-MMT) and G5 (MMT), both Buick Centuries with 2.5l 4 cylinder engines; H2 (non-MMT) and H4 (MMT), both Buick Centuries with 2.8l V6 engines; and F5 (non-MMT) and F3 (MMT) , both 1988 Ford Crown Victorias with 5.0l V8 engines. All non-MMT cars were tested on UTG, while the MMT cars were tested with UTG containing HITEC/3000 at the level of 0.031 g(Mn)/gal. All of these MMT vehicles received a final test with clear UTG. In some cases, the MMT vehicles received a second test on MMT fuel.

1.3 Mileage Accumulation Route

The route selected for mileage accumulation was 124 miles long and typically required three hours for completion, yielding an average speed of 40 miles per hour. The route was designed to include sections of travel at all common speeds. A chart illustrating the speed distribution for the route is contained in Attachment C. This chart was compiled from time and distance data taken from vehicle log books.

The directions supplied to the mileage accumulation drivers were as follows:

Leaving MVEL, turn left (East) on Plymouth Road.
From Plymouth Road, enter US-23 south.
From US-23 South, enter I-94 East.
Exit I-94 east at Cadieux, turn right at Cadieux.
From Cadieux, turn left on Jefferson Avenue.
From Jefferson Avenue, turn left on Nine Mile Road.
From Nine Mile Road, turn left on Middlebelt.
From Middlebelt, turn right on Eight Mile Road.
From Eight Mile Road, turn left on the Pontiac Trail.
From the Pontiac Trail, turn left on Plymouth Road.
From Plymouth Road, turn left into the MVEL.

All initial mileage accumulation was completed on vehicles #8888 and #0077 with Gulf commercial regular gasoline containing MMT from the commercial additive. Any mileage accumulated on Veh #0077 was completed using UTG containing MMT in the amount of 0.031 g(Mn)/gal. Mileage accumulated on any other vehicle was accomplished using one of these fuel mixtures. Those miles accumulated before September 6, 1990 used the first fuel mixture described, those after September 6 were acquired with the latter.

1.4 Analysis of Manganese in Fuel

The elemental analysis of Manganese in fuel was performed via the technique of X-ray Fluorescence Spectrometry (XRF). In all cases, samples were acquired as short term composites from nozzle streams. Samples were taken in four ounce french square bottles, and allowed to warm to room temperature before analysis.

The actual procedure was identical in all respects but two to the CFR procedure for analysis of lead in fuel. The two deviations are obvious; standard samples were prepared with the use of a commercial manganese in oil sample as the primary standard, and the XRF instrument was tuned to the appropriate emission line for manganese. In all cases of fuel for testing, samples were taken in duplicate, and both were analyzed. As was previously stated, if the analytical results indicated that the concentration of manganese in the test fuel was outside the limits of 0.029 to 0.033 g(Mn)/gal, the fuel was reblended to adjust its manganese level.

2.0 The Testing Site

All tests for the program were performed using the same dynamometer and analysis bench, MVEL Dyno 7. Testing is performed on a Clayton Hydrokinetic chassis dynamometer Model #ECE-50. As the vehicle is operated on the dynamometer, the exhaust gases are collected and diluted with a Horiba Constant Velocity Sampler (CVS) Model 20 and a small sample is retained in Tedlar bags. For all tests performed during this program, the CVS flow rate was set to 350 SCFM. The retained samples are analyzed using a Horiba Model AIA-23 NDIR analyzer for CO & CO2 analysis, a Beckman Model 951A NOx analyzer for nitrogen oxide analysis, and a Beckman Model 400 FID for hydrocarbon analysis.

Particulate measurements were completed using the standard CFR test procedure for diesel particulate testing, with one deviation. In traditional diesel testing, one filter pair is employed for each bag sample, but in the MMT testing program one filter pair was employed for the entire test. This change was instituted to increase the detection limit of the particulate measurement, as the mass increase of the filter elements was presumed to be very small. This change resulted in all FTP particulate results being reported as unweighted values, and was continued throughout the program.

Filters were purchased from Pallflex Products Corp, and were type T60A20, a glass fiber filter of 47 mm diameter. A sample was removed isokinetically from the center of the 10" diameter particulate tunnel during the test. Exhaust gases are conducted to the tunnel through 4" diameter, smooth wall, insulated, stainless steel pipe. Filters were weighed before and after each test using a CAHN model C-30 microbalance on its most sensitive range. The detection limit of this balance is one microgram, and to support this, the balance is contained in a temperature and humidity controlled room. All filters were allowed to equilibrate with the atmosphere in the balance room for several hours prior to any weighing. One operator performed all balance measurements.

2.1 Exhaust Manganese Analysis

Two types of manganese emission were deemed possible, those being emission as particulate or as a vapor phase. Vapor phase emission was unlikely, given the chemistry of Mn(I) compounds, but in the interest of completeness, one test was performed in such a way as to trap any volatile manganese compounds that might be emitted.

2.1.1 Analysis for Volatile Manganese

To trap any volatile compounds that may be emitted, a liquid nitrogen trap was placed immediately behind the particulate filter during a test in which the vehicle, a 1990 Ford Crown Victoria was fueled with a high concentration (1/8 g(Mn)/gal) of MMT. Normally, the sample passing through the filter would proceed directly to the dry gas meter, but for this one test, the flow was diverted into the cryogenic trap. After the completion of one LA-4 cycle, the trap was removed from the system, and its interior rinsed with hydrochloric acid (HCl). This acid was analyzed for manganese content. Since no manganese was found, it was concluded that any manganese emission must be in the form of a particulate.

2.1.2 Analysis for Airborn Manganese Emission

Analysis for manganese emitted as particulate was accomplished by acid hydrolysis of the filter elements. Each filter was placed in a clean 125 ml Erlenmeyer flask, and 3 ml of 37% HCl was added. The flask containing the filter and the acid was heated to near boiling for 30 minutes. At the end of this period, the flask was removed from the heat, and the liquid decanted from it. The filter and flask were rinsed with several small portions of water to bring the total of the washings plus acid to 20 ml. These 20 ml liquid samples were analyzed via atomic absorbance spectrometry for manganese content.

A Perkin Elmer model 306 Atomic Absorption Spectometer was used for these analyses. Since this is a single beam instrument without background correction, several precautions had to be taken to insure that any measured absorbance was due to manganese in solution, and not to some matrix effect. To alleviate the concerns of absorbance from

background, all samples were filtered prior to analysis, and several samples were spiked with manganese to measure the recovery. To compensate for the single beam nature of the instrument, blank readings were taken before and after each sample reading, and standard samples were read at the beginning, end, and with each page of analysis. Standard samples were prepared with 99.9999% pure manganese (II) nitrate. Check samples were prepared with Primary Standard quality Potassium Permanganate. A commercial sample of Manganese Tetroxide was used as a check sample to evaluate the digestion process, and a sample of manganous (II) chloride was prepared from the tetroxide, to verify the purity of the tetroxide.

Recovery from all spiked samples was adequate to dispel any concerns of matrix effects. Concentration measurements of manganous (II) nitrate, potassium permanganate, and manganous (II) chloride compared favorably. Results of tetroxide analysis indicated it to be of questional purity, with values ranging from 94% to 97%. Since mixed valence metal oxides are typically difficult to obtain in high purity, these results were taken as acceptable.

2.1.3 Analysis for Manganese Compound Type

Two of the parameters of interest in metal based particulate emission are particle size and oxidation state. Samples of the emitted particulate were recovered from testing filters and catalysts that had been exposed to manganese. Both samples were placed in an analytical electron microscope, JEOL model 2000FX, for particle size measurement, and were also analyzed via Electron Spectroscopy for Chemical Analysis (ESCA) with a Perkin Elmer Phi series model 5400 spectrometer to determine the oxidation state of the manganese compound emitted. These analyses were performed at the X-ray and Electron Microscopy laboratories of the University of Michigan college of Engineering.

2.2 Testing Sequence

All vehicle tests followed the same sequence, in that three different driving cycles were administered. These three cycles, the FTP, the HFET or highway cycle, and the NYCC or New York City Cycle were always performed in this same order. Only one change was instituted during the course of testing. The number of highway cycles was allowed to vary when it became clear that additional distance would be required to improve the significance of the manganese analysis for this cycle. After this change was instituted, any even number of highway cycles might be performed, up to a limit of six, or until the filter elements began to load to the point of restricting flow.

These three cycles were chosen to allow comparisons to be made of emissions in different types of driving conditions. The critical parameters in particulate emissions were expected to be average speed, exhaust volume, and exhaust volume change. In this regard, the FTP is

a cycle with numerous starts and stops, and average speed of about 20 MPH. By contrast the HFET has only one start and one stop, but average speed of about 48 MPH. The NYCC has many starts and stops, many long idle periods, and an average speed of about 14 MPH.

3.0 Results of Regulated and Unregulated Emissions Tests

A total of 165 tests were run during the course of the program. Due to the large number of tests, as well as the quantity of vehicles, results were compiled on spread sheets. Final copies of these spread sheets, arranged by the date of the initial test of each vehicle, appear in Attachment D. Each page of this attachment contains data from an individual vehicle. EPA assigned vehicle identification number appears near the top left corner of each sheet. The vehicles are described and correlated with these numbers in section 1.2 above.

Results of the manganese analyses are presented in the tables listed in Attachment D as "per-cent manganese emitted". In those cases where no manganese was input to the vehicle, the calculated result presented in the table assumes that there was 31 mg/gal Mn input to the vehicle, even though this was not the case. These numbers are presented in this fashion to allow a comparison to the tests where manganese was input to the vehicle.

Results of the microscopic analysis of the manganese containing deposition yielded a particle size range of 0.1 to 0.5 microns. This range represents the mass deposited on the filter element from the tunnel sample. Particle size is not relevant in microscopic inspection of the catalysts, since the manganese appears to be deposited as a continuous coating.

ESCA results from these two samples were compared to a standard sample of manganese tetroxide. The spectra acquired in all three cases were virtually identical. The conclusion drawn was that the manganese compound deposited on the catalyst, as well as the manganese compound emitted to the atmosphere, are both manganese tetroxide (Mn_3O_4).

3.1 Quality Control

All dynamometer emissions tests were subjected to the same rigorous data review as certification tests. All inputs are reviewed first on the site, then by computer, and given a final scan by hand. Tests performed on Ethyl vehicles received an additional review by the EPA Correlation Engineering Group of the Engineering Operations Division.

4.0 Summary

Several generalizations are possible from the data collected during the program. Some of the averaged results are summarized below.

A) American Vehicles

a)	Average Total Particulate w/o MMT	0.0075 g/mile
b)	Average Total Particulate w/ MMT	0.0479 g/mile
c)	Average Total Particulate w/ comm'l addit	0.0526 g/mile
d)	Average Total Particulate w/ HITEC	0.0424 g/mile

B) Canadian Vehicles

a)	Average Total Particulate w/ MMT	0.0280 g/mile

C) Ethyl Vehicles

a)	Average FTP HC for non-MMT Cars	0.322 g/mile
b)	Average FTP HC for MMT Cars	0.531 g/mile
c)	Average FTP NOX for non-MMT Cars	0.610 g/mile
d)	Average FTP NOX for MMT Cars	0.408 g/mile
f)	Average FTP CO for non-MMT Cars	2.829 g/mile
g)	Average FTP CO for non-MMT Cars	4.024 g/mile
h)	Particulate Emission from MMT Cars	0.047 g/mile
f)	Particulate Emission after MMT Removal	0.019 g/mile
i)	Particulate Emission of Control Cars	0.011 g/mile
j)	Average FTP Manganese Emission	16.3%

Numerous other such comparisons are possible, as are many direct comparisons to the data presented in the waiver application, but are beyond the intent of this report.

4767c

ENGINEERING OPERATIONS DIVISION
Fuel Analysis Report
Unleaded Test Gasoline (96 RON)

Supplier: Phillips Chemical — Date delivered: 16-Aug-90
Quantity: 5000 gallons — Batch: K-706

Proposed Use('s): Certification Test Fuel

Item	Method	Units	Target	Tested by: EOD Where: Tank #3 When: 17-Aug-90	Core Tank #3 17-Aug-90	OFFICIAL EOD VALUES
RVP	ASTM D 323	psi	9.0-9.2	9.1		9.1
Distillation	ASTM D 86					
initial boiling point		°F	75-95	87.8		88
5% evaporated		°F		108.2		108
10% evaporated		°F	120-135	123.2		123
20% evaporated		°F		148.7		149
30% evaporated		°F		178.8		179
40% evaporated		°F		207.1		207
50% evaporated		°F	200-230	222.6		223
60% evaporated		°F		231.5		232
70% evaporated		°F		243.0		243
80% evaporated		°F		263.8		264
90% evaporated		°F	300-325	305.7		306
95% evaporated		°F		340.1		340
end point		°F	415 MAX.	403.8		404
evaporated at 160 °F		Vol %		23.3		23
Sulfur	ASTM D 1266	wt%	0.01 MAX.		0.0036	0.0036
Lead	ASTM D 3237	g/gal	0.05 MAX.	0.004		0.004
Manganese	AA	g/gal				
Phosphorous	ASTM D 3231	g/gal	0.005 MAX.			<0.0001
Water (Wt%)	Karl Fische	Wt %				
Hydrocarbon Composition	ASTM D 1319			100.0		
olefins		Vol %	10 MAX.	2.6		2.6
aromatics		Vol %	35 MAX.	31.0		31.0
saturates		Vol %	REMAINDER	66.4		66.4
Research octane number	ASTM D 2699		96.0 MIN.		96.6	96.6
Motor octane number	ASTM D 2700				87.6	87.6
Antiknock index	ASTM D 439				92.1	92.1
Sensitivity	RON-MON		7.5 MIN.		9.0	9.0
Weight fraction carbon	ASTM D 2789					
Weight fraction carbon	ASTM E 191					
Weight fraction carbon	ASTM D 3343			0.8658		0.8658
Net heat of combustion	ASTM D 240	BTU/lb				
Net heat of combustion	ASTM D 3338	BTU/lb		18473.9		18473.4
API Gravity	ASTM D 1289	°API		58.6	58.7	58.6
Specific gravity (60°F/60°F)				0.7443	0.7440	0.7443
Fuel economy numerator (g carbon/gal)			2401-2441	2435		2435
Fuel economy numerator (g carbon/gal) with R Factor				2430		2430

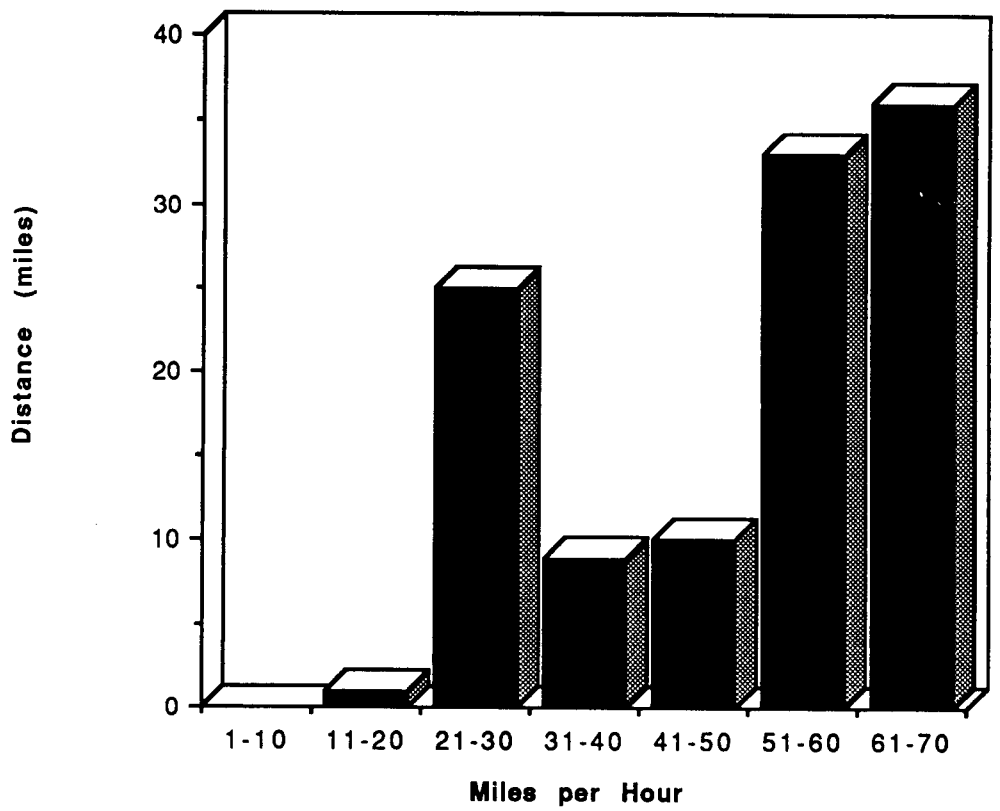
Attachment A

ENGINEERING OPERATIONS DIVISION
Fuel Analysis Report
Milage Accumulation Gasoline

				Before the Addition of MMT			After the Addition of MMT		
			Tested by:	F&CS	Core	Official EOD	F&CS	Core	Official EOD
			Where:	Tank #5	Tank #5	Tank #5	Tank #5	Tank #5	Tank #5
			When:	15-Jun-90	15-Jun-90	19-Jun-90	15-Jun-90	15-Jun-90	19-Jun-90
Item	Method	Units	Target						
RVP Herzog Digital	ASTM D 4953	psi		9.1		9.1	9.1		9.1
Distillation	ASTM D 86								
initial boiling point		°F		86.7		87	86.7		87
5% evaporated		°F		11.7		12	11.7		12
10% evaporated		°F	158 Max	123.9		124	123.9		124
20% evaporated		°F		142.5		143	142.5		143
30% evaporated		°F		162.1		162	162.1		162
40% evaporated		°F		186.0		186	186.0		186
50% evaporated		°F	170-250	214.5		215	214.5		215
60% evaporated		°F		243.3		243	243.3		243
70% evaporated		°F		275.0		275	275.0		275
80% evaporated		°F		312.0		312	312.0		312
90% evaporated		°F	374 Max	355.1		355	355.1		355
95% evaporated		°F		415.5		416	415.5		416
end point		°F	437 Max.	452.0		470	452.0		470
evaporated at 160 °F		Vol %		30.5		30.5	30.5		30.5
Sulfur	ASTM D 1266	wt%	0.10 MAX.		0.0662	0.0662		0.0699	0.0699
Lead	F&CS X-Ray	g/gal	0.05 MAX.	<0.005		<0.005	<0.005		<0.005
Manganese	F&CS X-Ray	g/gal	(a)	<0.005		<0.005	0.031		0.031
Phosphorous	ASTM D 3231	g/gal	0.005 MAX.		<0.0001	<0.0001		<0.0001	<0.0001
Water (Wt%)	Karl Fische	Wt %	(a)						
Hydrocarbon Composition	ASTM D 1319								
olefins		Vol %	(a)	9.1		9.1	9.1		9.1
aromatics		Vol %	(a)	27.9		27.9	27.9		27.9
saturates		Vol %	(a)	63.0		63.0	63.0		63.0
Research octane number	ASTM D 2699		(a)		90.6	90.6		91.7	91.7
Motor octane number	ASTM D 2700		(a)		82.2	82.2		83.0	83.0
Antiknock index	ASTM D 439		87.0		86.4	86.4		87.4	87.4
Sensitivity	RON-MON		(a)		8.4	8.4		8.7	8.7
Weight fraction carbon	ASTM D 2789		(a)						
Weight fraction carbon	ASTM E 191		(a)						
Weight fraction carbon	ASTM D 3343		(a)	0.8640		0.8640	0.8640		0.8489
Net heat of combustion	ASTM D 240	BTU/lb	(a)						
Net heat of combustion	ASTM D 3338	BTU/lb	(a)	18512.9		18503.5	18512.9		18878.9
API Gravity	ASTM D 1289	°API	(a)	59.6	59.3	59.6	59.6	59.3	59.6
Specific gravity (60°F/60°F)			(a)	0.7405	0.7416	0.7405	0.7405	0.7416	0.7405
Fuel economy numerator (g carbon/gal)			(a)	2417		2417	2417		2375
Fuel economy numerator (g carbon/gal) with R Factor				2417		2418	2417		2347

Attachment B

MMT Mileage Accumulation Route
17 August 1990



MFR	VEHICLE ID		MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%		DRIVER ID	DYNO	US Vehicle Leased by EPA
		1990 Taurus 3.0L V6									
30 FORD	A999EOD-8888	1FACP52U8LG159954	90	6.8	3625	18.0	7.2		56444	D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODOMETR READING	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emiss.	Mn Source	Filter Prim.	Number Sec.	AMBT °F	BAROM in. Hg	DEW POINT
904725	8/10/90	21	FTP	3883.5	0.204	3.676	431.0	0.505	20.3	0.0028	N			297	298	75.5	29.14	55.0
904739	8/14/90	21	FTP	3942.2	0.217	3.798	427.3	0.493	20.5	0.0492	Y		Other	311	312	75.5	29.23	52.8
904726	8/21/90	21	FTP	5564.5	0.265	4.436	434.1	0.576	20.1	0.0679	Y		Other	329	330	75.5	29.18	52.9
904727	8/23/90	21	FTP	6170.0	0.241	4.414	426.7	0.580	20.4	0.0642	Y	13.0%	Other	337	338	73.5	29.12	55.5
904729	8/27/90	21	FTP	7456.0	0.250	3.458	423.8	0.555	20.6	0.0832	Y	15.0%	Other	352	353	74.0	29.14	63.9
905021	9/6/90	21	FTP	11092.3	0.298	4.836	424.2	0.541	20.5	0.0553	Y	15.0%	Other	406	407	75.5	29.05	51.1
905191	9/7/90	21	FTP	11165.5	0.264	4.342	418.3	0.616	20.9	0.0079	N	0.0%		422	423	75.5	28.91	47.6
905194	9/10/90	21	FTP	11791.8	0.261	4.033	427.0	0.551	20.5	0.0038	N	3.0%		440	441	75.5	29.13	53.0
904728	9/13/90	21	FTP	11912.4	0.258	4.584	416.0	0.581	21.0	0.0246	Y	13.0%	HiTec	488	489	75.5	29.23	49.9
904738	8/10/90	21	HWY	3894.4	0.022	0.483	257.8	0.139	34.3	0.0049	N			299	300	75.0	29.13	54.4
904748	8/14/90	21	HWY	3953.0	0.022	0.419	261.3	0.225	33.9	0.0497	Y		Other	313	314	75.0	29.22	52.8
904772	8/21/90	21	HWY	5575.4	0.018	0.267	269.2	0.425	32.9	0.0700	Y		Other	331	332	75.2	29.18	52.9
904773	8/23/90	21	HWY	6180.9	0.021	0.254	264.3	0.309	33.6	0.0779	Y	6.1%	Other	339	340	72.5	29.12	56.1
904933	8/27/90	21	HWY	7666.9	0.021	0.329	268.9	0.388	32.9	0.1022	Y	7.3%	Other	354	355	74.5	29.14	66.3
904742	9/6/90	21	HWY	11103.2	0.031	0.420	261.1	0.293	33.9	0.0541	Y	16.0%	Other	408	409	76.0	29.01	54.2
905192	9/7/90	21	HWY	11176.5	0.027	0.365	261.1	0.201	33.9	0.0105	N	4.0%		424	425	76.0	28.93	49.4
905195	9/10/90	21	HWY	11802.7	0.020	0.263	264.6	0.247	33.5	0.0073	N	5.0%		442	443	76.0	29.15	56.7
904932	9/13/90	21	HWY	11923.4	0.028	0.475	259.1	0.211	34.3	0.0275	Y	7.0%	HiTec	490	491	75.5	29.21	49.5
904737	8/10/90	21	NYCC	3914.4	0.641	28.473	845.1	0.697	10.0	0.0054	N			301	302	75.5	29.13	55.0
904749	8/14/90	21	NYCC	3973.1	0.474	23.220	842.1	0.686	10.1	0.0363	Y		Other	315	316	75.5	29.22	52.8
904780	8/21/90	21	NYCC	5595.6	0.438	20.248	858.0	0.519	10.0	0.0431	Y		Other	333	334	75.5	29.18	53.9
904781	8/23/90	21	NYCC	6201.1	0.545	23.949	851.1	0.787	10.0	0.0477	Y	13.1%	Other	341	342	74.5	29.12	56.7
904783	8/27/90	21	NYCC	7487.1	0.236	5.799	824.4	0.813	10.6	0.0548	Y	9.1%	Other	356	357	73.5	29.14	49.1
904743	9/6/90	21	NYCC	11155.7	0.928	21.350	833.3	0.740	10.2	0.0570	Y	30.0%	Other	418	419	75.5	28.96	53.3
905193	9/7/90	21	NYCC	11196.7	0.663	20.620	828.1	0.765	10.3	0.0092	N	7.0%		426	427	75.5	28.93	49.4
905196	9/10/90	21	NYCC	11823.0	0.816	28.056	841.4	0.692	10.0	0.0196	N	11.0%		444	445	75.5	29.15	57.1
904782	9/13/90	21	NYCC	11963.8	0.947	27.521	812.0	0.67	10.4	0.0264	Y	29.0%	HiTec	492	493	75.5	29.21	49.9

All Particulate values are unweighted

MFR	VEHICLE ID	1990 Cavalier 2.2L 4 cyl	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 0.4	DRIVER ID	DYNO	US Vehicle Leased by EPA
		VIN								
40 GM	A999EOD-0099	1G1JC84GXLJ188325	90	5.6	2750	15.5	6.2	56444	D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODOMETR READING	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emiss.	Mn Source	Filter Prim.	Filter Sec.	AMBT °F	BAROM in. Hg	DEW POINT
904730	8/10/90	21	FTP	2160.5	0.164	2.116	335.0	0.189	26.2	0.0049	N			291	292	75.5	29.14	54.0
904731	8/14/90	21	FTP	2221.3	0.148	2.084	326.9	0.132	26.8	0.0258	Y		Other	305	306	75.0	29.23	48.0
904732	8/20/90	21	FTP	2908.7	0.139	1.838	324.0	0.159	27.1	0.0479	Y		Other	321	322	74.5	29.23	49.9
904733	8/24/90	21	FTP	3943.6	0.164	2.456	324.7	0.179	26.9	0.0435	Y	10.0%	Other	343	344	74.5	29.19	46.3
904734	8/28/90	21	FTP	5638.5	0.158	1.711	314.6	0.157	27.9	0.0393	Y	16.0%	Other	360	361	74.5	28.90	55.5
905019	9/5/90	21	FTP	8477.7	0.157	1.856	325.3	0.261	27.0	0.0496	Y	19.0%	Other	400	401	75.5	29.18	58.1
905020	9/11/90	21	FTP	9833.5	0.147	1.684	328.8	0.208	26.8	0.0284	Y	15.0%	HiTec	456	457	75.5	29.30	47.9
905312	9/17/90	21	FTP	10742.7	0.155	1.434	327.8	0.141	26.9	0.0082	Y	81.0% *	HiTec	542	543	77.0	29.38	46.0
904736	8/10/90	21	HWY	2171.7	0.127	1.841	208.8	0.058	41.8	0.0069	N			293	294	75.5	29.14	55.0
904746	8/14/90	21	HWY	2232.5	0.101	1.510	205.0	0.038	42.7	0.0300	Y		Other	307	308	75.5	29.23	51.8
904774	8/20/90	21	HWY	2919.9	0.058	0.927	201.8	0.034	43.6	0.0488	Y		Other	323	324	75.0	29.23	50.8
904775	8/24/90	21	HWY	3954.8	0.101	2.008	198.6	0.052	43.8	0.0610	Y	10.0%	Other	345	346	74.0	29.20	47.1
904934	8/28/90	21	HWY	5649.0	0.052	0.755	196.6	0.063	44.8	0.0609	Y	9.0%	Other	362	363	74.5	28.89	56.5
904740	9/5/90	21	HWY	8488.9	0.059	0.796	202.5	0.062	43.6	0.0536	Y	10.0%	Other	402	403	75.5	29.19	52.9
905018	9/11/90	21	HWY	9844.7	0.053	0.577	208.4	0.067	42.6	0.0330	Y	10.0%	HiTec	458	459	76.0	29.31	47.9
905313	9/17/90	21	HWY	10753.9	0.079	0.656	206.4	0.046	42.9	0.0151	Y	18.0% *	HiTec	544	545	77.3	29.38	44.2
904735	8/10/90	21	NYCC	2192.5	0.159	3.448	682.7	0.437	12.9	0.0062	N			295	296	75.5	29.14	54.0
904747	8/14/90	21	NYCC	2253.2	0.090	2.950	655.4	0.400	13.4	0.0374	Y		Other	309	310	75.5	29.23	53.8
904776	8/20/90	21	NYCC	2940.6	0.125	3.334	660.9	0.431	13.3	0.0464	Y		Other	327	328	75.5	29.23	50.8
904777	8/24/90	21	NYCC	3975.5	0.140	3.074	670.5	0.431	13.1	0.0454	Y	6.0%	Other	347	348	73.5	29.20	47.1
904778	8/28/90	21	NYCC	5670.0	0.089	0.874	651.9	0.443	13.6	0.0340	Y	7.0%	Other	364	365	74.5	28.88	55.5
904741	9/5/90	21	NYCC	8509.7	0.179	3.041	619.0	0.497	14.2	0.0436	Y	14.0%	Other	404	405	75.5	29.19	52.9
904779	9/11/90	21	NYCC	9886.2	0.133	2.797	662.2	0.884	13.3	0.0423	Y	44.0%	HiTec	460	461	75.5	29.31	48.8
905314	9/17/90	21	NYCC	10816.2	0.182	8.494	651.3	0.178	13.4	0.0196	Y	66.0% *	HiTec	546	547	77.0	29.38	44.2
90PartOnly	9/13/90	21	LA4's	???						0.0280	Y		HiTec	504	505		29.21	

* After 700 miles @ 1 gr/gal Mn and 300 miles @ 1/32 gr/gal, all Hitec 3000

All Particulate values are unweighted

MFR	VEHICLE ID	1990 Cavalier 2.2L 4 cyl	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	Canadian Vehicle leased by EPA
	VIN									
40 GM	A999EOD-0011	1G1CT51G9LY137286	90	6.2	3000	15.6	6.2		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODOMETR READING	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn% Emiss.	Mn Source	Filter Prim.	Number Sec.	AMBT °F	BAROM in. Hg	DEW POINT
905055	8/29/90	21	FTP	24338.0	0.208	1.753	360.2	0.231	24.4	0.0193	Y	9.7%	other	376	377	76.5	28.93	52.3
905099	9/12/90	21	FTP	25915.5	0.202	2.537	357.5	0.313	24.6	0.0317	Y	149.0%	HiTec	478	479	76.5	28.93	52.3
905557	9/21/90	21	FTP	26491.8	0.208	2.660	365.0	0.313	24.1	0.0387	Y	9.4%	HiTec	552	553	76.5	29.04	50.2
905056	8/29/90	21	HWY	24356.0	0.035	0.320	245.3	0.100	36.1	0.0710	Y	3.3%	other	378	379	76.5	28.93	52.3
905100	9/12/90	21	HWY	25933.2	0.035	0.381	304.2	0.078	29.2	0.0375	Y	21.0%	HiTec	480	481	76.0	29.24	49.3
905558	9/21/90	21	HWY	26509.6	0.037	0.433	268.4	0.079	33.1	0.0867	Y	2.8%	HiTec	554	555	76.5	29.04	53.1
905057	8/29/90	21	NYCC	24389.0	0.199	1.023	670.0	0.640	13.2	0.0084	Y	6.5%	other	380	381	76.5	28.93	52.3
905101	9/12/90	21	NYCC	25982.2	0.234	7.939	699.2	0.484	12.5	0.0407	Y	58.0%	HiTec	482	483	75.5	29.22	50.8
905559	9/21/90	21	NYCC	26542.5	0.309	4.460	693.2	0.907	12.7	0.0224	Y	4.8%	HiTec	556	557	76.0	29.02	51.2
905560	9/21/90	21	LA4's	26546.2	0.034	0.585	382.3	0.143	23.2	0.0420	Y	11.0%	HiTec	558	559	76.5	29.00	51.6

Bag 2 Emissions Only

All Particulate values are unweighted

MFR	VEHICLE ID	1990 GMC 3/4 Ton Van V8	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	Canadian Vehicle leased by EPA
	VIN									
40 GM	A999EOD-0021	2GCEG25Z0K4145937	89	11.1	5000	22	8.8		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODOMETR KILOM.	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emis.	Mn Source	Filter Prim.	Filter Sec.	AMBT °F	BAROM in. Hg	DEW POINT
905070	8/29/90	21	FTP	53522.0	0.811	8.344	510.1	0.659	16.9	0.0389	Y	37.0%	Other	368	369	74.5	28.94	50.4
905096	8/31/90	21	FTP	54348.1	1.016	9.533	510.7	0.737	16.8	0.0215	Y	50.0%	Other	386	387	75.5	29.19	52.9
905364	9/13/90	21	FTP	54964.7	0.606	9.222	515.3	0.508	16.8	0.0077	N	57.8%		494	495	75.5	29.15	51.0
905409	9/14/90	21	FTP	55098.5	0.680	9.427	509.8	0.497	16.9	0.0059	Y	19.3%	HiTec	514	515	75.5	28.78	50.7
905435	9/17/90	21	FTP	56420.5	0.620	8.614	519.7	0.523	16.6	0.0063	Y	28.3%	HiTec	530	531	76.5	29.33	45.2
905071	8/29/90	21	HWY	53540.0	0.150	4.452	365.2	0.198	23.8	0.1269	Y	5.0%	Other	370	371	75.0	28.93	51.4
905097	8/31/90	21	HWY	54359.5	0.132	4.329	377.6	0.210	23.0	0.0756	Y	4.0%	Other	388	389	75.5	29.19	53.9
905365	9/13/90	21	HWY	54982.7	0.051	1.651	377.0	0.136	23.4	0.0069	N	4.0%		496	497	75.5	29.11	51.0
905410	9/14/90	21	HWY	55116.6	0.058	2.020	379.3	0.142	23.3	0.0077	Y	4.3%	HiTec	516	517	76.2	28.71	51.8
905436	9/17/90	21	HWY	56438.6	0.058	2.322	379.3	0.118	23.3	0.0100	Y	6.0%	HiTec	532	533	76.5	29.33	45.0
905072	8/29/90	21	NYCC	53573.0	2.484	11.067	896.0	1.201	9.6	0.0205	Y	34.0%	Other	372	373	75.5	28.96	51.3
905098	8/31/90	21	NYCC	54392.0	2.540	11.048	925.0	1.354	9.3	0.0193	Y		Other	390	391	75.5	29.21	53.8
905366	9/13/90	21	NYCC	55082.6	1.248	21.028	899.7	0.681	9.5	0.0157	N	26.0%		498	499	75.5	29.11	49.1
905411	9/14/90	21	NYCC	55216.3	1.573	23.323	899.5	0.743	9.5	0.0195	Y	22.0%	HiTec	518	519	75.5	28.71	62.9
905437	9/17/90	21	NYCC	56538.2	1.424	22.788	926.3	0.766	9.2	0.0204	Y	23.0%	HiTec	534	535	76.0	29.37	46.9

All Particulate values are unweighted

A999EOD-0031 9/25/90

MFR	VEHICLE ID	1990 Chev. 1/2 Ton Van V8	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	Canadian Vehicle leased by EPA
		VIN								
40 GM	A999EOD-0031	9999.0	90	13.6	5000	22	8.8		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODOMETR KILOM.	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emis.	Mn Source	Filter Prim.	Number Sec.	AMBT °F	BAROM in. Hg	DEW POINT
905427	9/14/90	21	FTP	13383.9	0.526	5.318	493.3	0.688	17.7	0.0063	Y	11.3%	HiTec	508	509	75.5	28.92	54.4
905432	9/17/90	21	FTP	14761.2	0.531	4.077	505.2	0.596	17.3	0.0042	Y	11.0%	HiTec	536	537	76.5	29.39	47.7
905428	9/14/90	21	HWY	13401.8	0.056	0.990	372.3	0.180	23.8	0.0175	Y	4.1%	HiTec	510	511	76.0	28.91	48.5
905433	9/17/90	21	HWY	14779.1	0.059	1.550	384.3	0.139	23.0	0.0126	Y	4.3%	HiTec	538	539	76.5	29.39	47.7
905429	9/14/90	21	NYCC	13500.7	2.108	21.759	840.2	0.551	10.1	0.0255	Y	24.1%	HiTec	512	513	75.5	28.85	50.9
905434	9/17/90	21	NYCC	14878.0	1.794	15.688	882.0	0.388	9.8	0.0143	Y	12.8%	HiTec	540	541	77.0	29.39	45.8

All Particulate values are unweighted

MFR	VEHICLE ID	1990 Cavalier 2.2L 4 cyl	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	US Vehicle Leased by EPA
		VIN								
40 GM	A999EOD-0077	1G1JC84G2LJ187797	90	3.8	2750	15.5	6.2		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODOMETR READING	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emis.	Mn Source	Filter Number Prim.	Filter Number Sec.	AMBT °F	BAROM in. Hg	DEW POINT
905135	8/31/90	21	FTP	3200.0	0.086	0.899	331.7	0.217	26.6	0.0039	N	1.0%		392	393	75.5	29.23	55.9
905179	9/6/90	21	FTP	3242.8	0.095	1.371	330.4	0.236	26.7	0.0089	N	0.0%		414	415	75.5	28.92	57.5
905180	9/7/90	21	FTP	3284.8	0.091	1.279	328.3	0.192	26.9	0.0109	Y	7.1%	HiTec	428	429	75.5	28.99	49.3
905181	9/14/90	21	FTP	4251.5	0.109	1.765	330.6	0.193	26.6	0.0107	Y	13.9%	HiTec	520	521	76.0	28.65	46.2
905136	8/31/90	21	HWY	3211.5	0.009	0.052	208.3	0.033	42.7	0.0225	N	0.0%		394	395	75.5	29.23	54.8
905183	9/6/90	21	HWY	3254.0	0.011	0.080	204.9	0.024	43.3	0.0286	N	1.0%		416	417	76.0	28.90	54.4
905184	9/7/90	21	HWY	3296.1	0.015	0.103	206.7	0.021	42.8	0.0203	Y	8.0%	HiTec	430	431	76.0	29.00	52.4
905185	9/14/90	21	HWY	4262.7	0.014	0.123	207.2	0.020	43.0	0.0677	Y	5.1%	HiTec	522	523	76.2	28.65	52.4
905137	8/31/90	21	NYCC	3232.6	0.028	0.127	660.5	0.434	13.4	0.0118	N	1.0%		396	397	75.5	29.23	55.9
905187	9/6/90	21	NYCC	3274.8	0.076	1.885	655.0	0.445	13.5	0.0114	N	0.0%		420	421	76.0	28.90	54.4
905188	9/7/90	21	NYCC	3316.9	0.066	1.548	654.5	0.447	13.5	0.0145	Y	8.3%	HiTec	432	433	75.5	29.01	52.2
905189	9/14/90	21	NYCC	4325.0	0.076	3.711	662.2	0.456	13.3	0.0177	Y	18.2%	HiTec	524	525	76.5	28.65	48.6

All Particulate values are unweighted

MFR	VEHICLE ID	1990 Taurus 3.0L V6	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	US Vehicle Leased by EPA
	VIN									
30 Ford	A999EOD-0024	1FACP552UMLG159952	90	6.8	3625	18	7.2		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODOMETR READING	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emiss.	Mn Source	Filter Prim.	Number Sec.	AMBT °F	BAROM in. Hg	DEW POINT
905307	9/11/90	21	FTP	11508.0	0.272	3.526	424.6	0.762	20.6	0.0040	N	0.0%		462	463	75.5	29.32	49.7
905327	9/12/90	21	FTP	11548.6	0.269	2.996	419.4	0.806	21.0	0.0306	Y	5.6%	HiTec	472	473	75.5	29.23	49.9
905308	9/11/90	21	HWY	11518.9	0.012	0.159	253.9	0.445	35.0	0.0092	N	0.0%		464	465	76.0	29.31	50.7
905328	9/12/90	21	HWY	11559.5	0.012	0.160	251.7	0.490	35.3	0.0300	Y	5.5%	HiTec	474	475	76.0	29.24	49.9
905309	9/11/90	21	NYCC	11521.2	0.517	24.799	836.9	0.766	10.1	0.0111	N	0.0%		466	467	75.5	29.31	51.7
905329	9/12/90	21	NYCC	11609.7	0.634	26.693	826.6	0.581	10.2	0.0386	Y	18.7%	HiTec	476	477	76.0	29.26	55.8

All Particulate values are unweighted

MFR	VEHICLE ID	1991 Sunbird 2.0L 4 cyl VIN	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	US Vehicle Leased by EPA
40 GM	A999EOD-0041	1G2JB54K2M7506339	91	5.6	2875	13.6	5.4		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. Miles	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emiss.	MN Source	Filter Prim.	Number Sec.	AMBT °F	BAROM in. Hg	DEW POINT
905620	9/25/90	21	FTP	4170.4	0.130	2.567	338.9	0.175	25.9	0.0027	N	0.0%		564	565	76.5	28.84	48.7
905678	9/28/90	21	FTP	4252.8	0.129	3.500	329.2	0.098	26.6	0.0282	Y	6.6%	HiTec	603	604	75.5	29.18	47.2
910027	10/2/90	21	FTP	4335.0	0.114	3.318	337.8	0.122	25.9	0.0377	Y	8.1%	HiTec	617	618	75.5	29.21	44.5
905622	9/25/90	21	HWY	4181.4	0.100	3.051	212.7	0.028	40.9	0.0032	N	0.2%		566	567	76.7	28.78	51.0
905623	9/28/90	21	HWY	4263.8	0.143	6.346	207.2	0.050	40.9	0.0450	Y	6.9%	HiTec	607	608	75.0	29.18	50.0
910028	10/2/90	21	HWY	4346.0	0.085	3.533	211.9	0.041	40.9	0.0681	Y	4.0%	HiTec	619	620	75.9	29.23	50.3
905621	9/25/90	21	NYCC	4242.9	0.040	3.911	707.6	0.469	12.5	0.0125	N	0.0%		568	569	76.5	28.78	53.6
905624	9/28/90	21	NYCC	4325.1	0.050	2.732	668.1	0.236	13.2	0.0659	Y	20.9%	HiTec	609	610	75.5	29.18	51.9
910029	10/2/90	21	NYCC	4387.1	0.058	3.478	727.2	0.153	12.1	0.0392	Y	8.9%	HiTec	621	622	76.0	29.24	51.8

All Particulate values are unweighted

MFR	VEHICLE ID		1991 Dynasty 3.3L V6			MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%		DRIVER ID	DYNO	US Vehicle Leased by EPA
	VIN													
20 Chry	A999EOD-0051		1B3XC46R3M0103206			91	8.5	3375	16	6.4			D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. MILES	HC-HFID g/mi	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emiss.	MN Source	Filter Prim.	Number Sec.	AMBT °F	BAROM in. Hg	DEW POINT
905614	9/25/90	21	FTP	2126.0		0.290	2.137	426.6	0.423	20.6	0.0030	N	0.0%		570	571	76.5	28.78	53.6
905634	9/26/90	21	FTP	2209.0		0.332	2.025	425.5	0.506	20.7	0.1275	Y	10.4%	HiTec	579	580	76.5	28.83	47.8
905677	9/28/90	21	FTP	2250.0		0.288	2.067	428.2	0.415	20.6	0.0950	Y	14.7%	HiTec	611	612	75.5	29.18	51.9
910024	10/2/90	21	FTP	2292.0		0.299	2.157	428.6	0.397	20.5	0.1189	Y	13.4%	HiTec	623	624	75.5	29.24	42.8
910276	10/5/90	21	FTP	2344.0		0.279	1.865	424.1	0.378	20.8	0.0547	Y	To ORD	HiTec	689	690	75.5	29.02	50.2
910364	10/12/90	21	FTP	2416.0	0.318	0.290	1.939	422.2	0.421	20.9	0.0775	Y	9.4%	HiTec	775	776	75.5	29.15	50.0
905617	9/25/90	21	HWY	2137.0		0.087	0.446	289.7	0.094	30.6	0.0015	N	0.08%		572	573	76.4	28.75	54.1
905635	9/26/90	21	HWY	2220.0		0.065	0.508	287.3	0.068	30.9	0.1348	Y	6.3%	HiTec	581	582	76.0	28.86	47.7
905618	9/28/90	21	HWY	2261.0		0.068	0.576	291.7	0.065	30.4	0.1156	Y	8.8%	HiTec	613	614	75.3	29.17	54.1
910025	10/2/90	21	HWY	2303.0		0.059	0.558	286.3	0.074	31.0	0.1164	Y	9.3%	HiTec	625	626	75.3	29.22	40.7
910277	10/5/90	21	HWY	2355.0		0.059	0.546	284.3	0.073	31.2	0.0404	Y	To ORD	HiTec	691	692	75.0	29.03	49.5
910365	10/12/90	21	HWY	2427.0	0.073	0.063	0.607	281.3	0.079	31.5	0.0747	Y	4.3%	HiTec	777	778	76.5	29.15	52.3
910591	10/25/90	21	HWY	2460.0		0.056	0.592	275.0	0.055	32.2	0.1685	Y		HiTec	793	794	75.5	29.15	44.9
910592	10/25/90	21	HWY	2480.0		0.046	0.521	279.7	0.071	31.7	0.1610	Y		HiTec	795	796	75.5	29.16	45.4
910593	10/25/90	21	HWY	2516.0		0.067	0.512	282.9	0.125	31.4	0.1212	Y	0.1% S	HiTec	797	798	75.4	29.18	45.4
910594	10/25/90	21	HWY	2537.0		0.075	0.943	282.4	0.158	31.3	0.1342	Y	0.1% S	HiTec	799	800	75.5	29.18	44.5
905616	9/25/90	21	NYCC	2199.0		0.140	0.695	844.5	0.878	10.5	0.0127	N	0.0%		574	575	76.5	28.72	58.9
905636	9/26/90	21	NYCC	2240.0		0.343	2.052	831.2	1.025	10.7	0.0918	Y	8.2%	HiTec	583	584	76.5	28.87	46.8
905619	9/28/90	21	NYCC	2282.0		0.273	2.196	831.3	0.728	10.7	0.0834	Y	23.1%	HiTec	615	616	75.5	29.16	53.9
910026	10/2/90	21	NYCC	2334.0		0.185	1.558	839.8	0.622	10.6	0.1070	Y	19.2%	HiTec	627	628	75.5	29.21	41.2
910278	10/5/90	21	NYCC	2406.0		0.181	1.939	839.5	0.552	10.6	0.0236	Y	To ORD	HiTec	693	694	75.5	29.03	50.2
910366	10/12/90	21	NYCC	2457.0	0.325	0.298	0.933	821.0	1.024	10.8	0.0826	Y	7.3%	HiTec	779	780	76.0	29.14	54.0

All Particulate values are unweighted

MFR	VEHICLE ID	1988 Buick Century 2.5L 4 cyl	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	Ethyl Test Vehicle
	VIN									loaned to EPA
40 GM	A999EOD-0015	1G4AH51R8JT450644	88	6.3	3000	15.5	6.2		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. Miles	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emiss.	MN Source	Filter Prim.	Number Sec.	AMBT °F	BAROM in. Hg	DEW POINT
910133	10/3/90	21	FTP	75411.3	0.156	2.799	333.6	0.315	26.3	0.0038	N	0.7%		635	636	75.5	29.18	47.2
910134	10/3/90	21	HWY	75422.5	0.036	0.491	227.8	0.156	38.9	0.0067	N	0.0%		637	638	75.8	29.16	50.0
910135	10/3/90	21	NYCC	75484.5	0.263	8.659	642.3	0.536	13.6	0.0235	N	0.0%		639	640	75.5	29.14	48.2

All Particulate values are unweighted

MFR	VEHICLE ID	1988 Buick Century 2.5L 4 cyl	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	Ethyl Test Vehicle
	VIN									loaned to EPA
40 GM	A999EOD-0016	1G4AH51RXJT450743	88	6.3	3000	15.5	6.2		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. Miles	HC-HFID g/mi	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Y/N	Mn% Emiss.	MN Source	Filter Prim.	Number Sec.	AMBT °F	BAROM in. Hg	DEW POINT
910130	10/3/90	21	FTP	75506.5		0.221	3.769	355.4	0.389	24.6	0.0203	Y	19%	HiTec	647	648	75.5	28.85	57.7
910338	10/17/90	21	FTP	75576.1	0.215	0.189	3.146	342.0	0.363	25.6	0.0124	N	34%		785	786	75.5	29.01	53.2
910131	10/3/90	21	HWY	75517.6		0.050	0.730	238.3	0.279	37.2	0.0505	Y	5.6%	HiTec	649	650	75.3	28.85	58.3
910334	10/17/90	21	HWY	75587.2	0.111	0.046	0.616	236.9	0.243	37.4	0.0180	N	7.1%		787	788	75.0	29.01	52.2
910132	10/3/90	21	NYCC	75558.7		0.408	8.376	670.8	0.696	13.0	0.0206	Y	13%	HiTec	651	652	75.5	28.85	58.8
910336	10/17/90	21	NYCC	75648.6	0.270	0.245	9.343	668.3	0.655	13.0	0.0232	N	25%		789	790	75.5	28.87	51.9

All Particulate values are unweighted

MFR	VEHICLE ID	1988 Buick Century 2.8L V6	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	Ethyl Test Vehicle
	VIN									loaned to EPA
40 GM	A999EOD-0017	1G4AH51WXJT451509	88	6.3	3125	15.5	6.2		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. Miles	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emiss.	MN Source	Filter Number Prim.	Filter Number Sec.	AMBT °F	BAROM in. Hg	DEW POINT
910142	10/3/90	21	FTP	77473.2	0.295	3.635	387.4	0.355	22.6	0.0049	N	0.6%		641	642	75.5	29.07	54.1
910143	10/3/90	21	HWY	77484.3	0.018	0.106	250.8	0.503	35.5	0.0059	N	0.0%		643	644	75.3	29.07	53.9
910144	10/3/90	21	NYCC	77545.2	0.438	5.228	723.7	1.087	12.1	0.0271	N	0.0%		645	646	75.5	29.07	56.2

All Particulate values are unweighted

MFR	VEHICLE ID	1988 Buick Century 2.8L V6	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	Ethyl Test Vehicle
		VIN								loaned to EPA
40 GM	A999EOD-0018	1G4AH51W4JT451537	88	6.3	3125	15.5	6.2		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. Miles	HC-HFID g/mi	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emiss.	MN Source	Filter Number Prim.	Filter Number Sec.	AMBT °F	BAROM in. Hg	DEW POINT
910212	10/4/90	21	FTP	75255.7	0.247	0.377	3.852	402.7	0.232	21.7	0.0366	Y	11%	HiTec	669	670	75.5	28.92	46.7
910340	10/10/90	21	FTP	75337.7	0.512	0.507	5.361	401.2	0.249	21.7	0.0812	Y	27%	HiTec	711	712	75.5	28.86	62.1
910341	10/11/90	21	FTP	75379.0	0.363	0.354	3.777	397.2	0.251	22.0	0.0146	N	5.5%		733	734	75.5	29.24	46.2
910213	10/4/90	21	HWY	75266.7	0.080	0.028	0.243	252.1	0.048	35.2	0.0344	Y	6.5%	HiTec	671	672	75.0	28.92	47.2
910342	10/10/90	21	HWY	75348.7	0.037	0.037	0.467	250.3	0.059	35.4	0.0838	Y	5.8%	HiTec	713	714	75.5	28.86	51.3
910343	10/11/90	21	HWY	75390.0	0.011	0.016	0.165	250.7	0.115	35.5	0.0133	N	2.0%		735	736	75.6	29.24	46.2
910214	10/4/90	21	NYCC	75327.8	0.696	0.680	8.426	761.3	1.024	11.5	0.0471	Y	18%	HiTec	673	674	75.5	28.94	47.8
910344	10/10/90	21	NYCC	75369.1	1.021	0.989	10.491	751.2	0.741	11.5	0.0527	Y	8.1%	HiTec	715	716	75.5	28.85	53.5
910345	10/11/90	21	NYCC	75451.2	0.532	0.590	7.533	734.8	0.921	11.9	0.0323	N	4.3%		737	738	75.5	29.24	46.2

All Particulate values are unweighted

MFR	VEHICLE ID	1988 Crown Victoria 5.0L V8	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	Ethyl Test Vehicle loaned to EPA
30 Ford	A999EOD-0019	2FABP73F2JX216499	89	11.4	4000	18	7.2		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. Miles	HC-HFID g/mi	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn% Emiss.	MN Source	Filter Prim.	Filter Sec.	AMBT °F	BAROM in. Hg	DEW POINT
910491	10/4/90	21	FTP	72091.0	N/A	0.515	2.054	458.3	1.161	19.3	0.0072	N	0.6%		679	680	75.5	28.96	45.7
910492	10/4/90	21	HWY	72102.0	0.103	0.089	0.109	286.7	0.405	31	0.0019	N	0.35%		675	676	75.0	28.93	46.2
910493	10/4/90	21	NYCC	72162.0	0.920	0.917	2.523	902.0	2.151	9.8	0.0186	N	0.7%		677	678	75.5	28.93	43.2

All Particulate values are unweighted

A999EOD-0020 10/11/90

MFR	VEHICLE ID	VIN	MODEL	RLHP	EQWT	FUEL CAP.	FUEL 40%	DRIVER ID	DYNO	Ethyl Test Vehicle loaned to EPA
30 Ford	A999EOD-0020	2FABP73F9JX216497	89	11.4	4000	18	7.2		D007	

TEST NO	TEST DATE	TEST TYPE	TEST PROC.	ODO. Miles	HC-HFID g/mi	HC g/mi	CO g/mi	CO2 g/mi	NOX g/mi	MPG	PART g/mi	Mn Yes/No	Mn % Emiss.	MN Source	Filter Prim.	Number Sec.	AMBT °F	BAROM in. Hg	DEW POINT
910206	10/4/90	21	FTP	72530.0	0.855	0.857	2.373	461.3	0.612	19.0	0.0356	Y	11%	HiTec	681	682	75.5	28.92	49.5
910328	10/10/90	21	FTP	72618.0	1.130	1.093	5.018	458.8	0.576	18.9	0.1083	Y	11%	HiTec	705	706	75.5	28.90	51.4
910329	10/11/90	21	FTP	72669.0	0.748	0.709	1.234	459.8	0.625	19.2	0.0105	N	4.2%		727	728	75.5	29.16	43.7
910207	10/4/90	21	HWY	72541.0	0.314	0.301	0.116	291.2	0.247	30.4	0.0200	Y	6.3%	HiTec	683	684	75.0	28.94	48.5
910330	10/10/90	21	HWY	72629.0	0.386	0.372	0.405	290.1	0.251	30.5	0.0910	Y	4.9%	HiTec	707	708	75.7	28.89	53.4
910331	10/11/90	21	HWY	72679.0	0.235	0.224	0.064	287.9	0.309	30.8	0.0124	N	1.2%		729	730	75.3	29.19	44.5
910208	10/4/90	21	NYCC	72601.0	2.053	1.943	3.124	922.4	1.191	9.5	0.0396	Y	16%	HiTec	685	686	75.5	28.94	48.5
910309	10/4/90	21	NYCC	72604.0	2.172	2.010	4.388	915.6	1.249	9.6	0.0264	Y	6.2%	HiTec	687	688	75.5	28.94	48.5
910332	10/10/90	21	NYCC	72659.0	2.964	2.802	10.974	894.4	1.359	9.7	0.0722	Y	6.9%	HiTec	709	710	75.5	28.88	56.6
910333	10/11/90	21	NYCC	72740.0	1.012	0.967	0.244	910.8	1.451	9.7	0.0408	N	3.5%		731	732	75.5	29.23	45.3

All Particulate values are unweighted